THE APPLICATION OF GASIFICATION TECHNOLOGY TO PRODUCE TRANSPORTATION FUELS

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The genesis of the alternative fuels industry at the end of the 1970's was based on the expectation of ever-increasing crude oil prices throughout the rest of the century. Fortunately, or unfortunately, depending on one's perspective, this has not come to pass. Recent worldwide crude oil prices have dipped to record lows in recent months and the OPEC countries have not demonstrated the ability to cope with the challenges of controlling crude oil production to counter the increases of supply from geographically diverse regions of the world. Further shadowing the energy market is the potential for Iraq to reenter the world market with their crude production and the potential for the former states of the Soviet Union to upgrade and increase the export of crude oil into the world markets to raise much needed foreign currency.

These factors, combined with the significant reduction in federal support for the development of synthetic fuels in the early 1980's, have forced many companies to rethink their original strategy to enter the alternative energy business.

At Texaco, the development of alternative energy sources has been largely focused on gasification technologies that would convert a carbon source like coal and organic waste streams to produce syngas, a combination of primarily carbon monoxide (CO) and hydrogen. These products can be converted to steam and electricity through combined cycle turbines, or converted to methanol or synthetic gasoline as a potential transportation fuel or feedstock for chemical manufacturing. In addition, the application of gasification technologies can be used to provide hydrogen that will be necessary for refiners to produce reformulated gasolines in the future.

While this technology has been repeatedly demonstrated to be technically successful, the economics of the energy market have forced a refocusing of the marketing strategy. The proliferation of environmental requirements on stationary sources of air pollution under the Clean Air Act Amendments of 1990, together with restrictions placed on waste disposal by the federal Resource Conservation and Recovery Act Amendments passed in 1984, has created new opportunities for gasification technology. This technology is ideally suited to produce energy from coal or waste materials that significantly reduce the environmental impacts of coal or waste combustion for power generation.

To quantify the environmental and economic benefits of gasification technology over alternatives, it is necessary to identify the environmental media that are of concern. Air pollution emissions of particulate matter, oxides of nitrogen (NOx), and sulfur dioxide (SO2) are the principal air pollution concerns from coal combustion. Carbon dioxide (CO2) emissions, a greenhouse gas, are not considered an air pollutant; however, they are a concern, given the current commitments by the federal government to reduce the U.S. CO2 emissions over the next decade. Finally, the generation and disposal of solid waste materials including ash, scrubber sludge, petroleum coke, plastics, municipal wastewater sludge, and industrial waste is an important environmental concern throughout much of the industrialized world.

As will be presented in more detail later in this paper, gasification technologies can present a number of environmental advantages over other methods of coal combustion for power generation or the manufacture of synthetic fuels. Not only are the generation of solid wastes reduced using gasification technology, but the application of gasification technologies can also convert waste materials, including hazardous wastes, to syngas and other desirable forms of energy. Quantifying the value of these advantages is critical to determining the economic attractiveness of any particular gasification technology and its ability to compete.

In comparing a gasification technology with alternatives, it is necessary to establish a set of standard operating assumptions as a common basis. These assumptions are shown in Table 1. Note that these assumptions are based on the configuration of a 250 megawatt power plant and indicate the appropriate coal capacities for the three types of competing technologies -- Texaco advanced gasification with combined cycle electricity generation (TAGCC); pulverized coal with scrubbers (PCWS); and pressurized fluidized bed combustion (PFBC).

Based on the above operating conditions, an estimate of the annual emissions of air pollutants and production of solid waste is shown in Table 2. The information provided is based on emission factors shown in parentheses on the table for each technology. The factors for the PCWS and PFBC technologies are derived from an Electric Power Research Institute Technical Assessment Guideline published in 1991. Emissions factors for the TAGCC technology are derived from work done by Texaco. Using TAGCC technology in lieu of the alternatives provides significant reductions in SOx, NOx, particulate matter, CO2, and solid waste production.

The valuation of these emission reductions is a function of the environmental standards adopted for air pollution limits and waste disposal transportation costs and treatment requirements. These costs can be expected to vary significantly from one location to another.

To provide further insight into this issue of valuation, an Externality Valuation comparison of TAGCC with PFBC and PCWS technologies is shown on Tables 3 and Table 4, respectively. The emissions reduced represent the total emissions stream differential over the twenty-year life of a project. The values per ton are based on an estimate from a study of externality costs conducted by Pace University in 1992 that estimated the cost per ton of emissions reduced for various air pollutants, including CO_2. Solid waste disposal costs assume a twenty-dollar-per-ton transportation charge for disposal. In these tables, the cost numbers are unadjusted for inflation and calculated on a straight-line basis. The emissions and waste reductions achieved from these technologies is substantial. As illustrated in the lower right-hand corner of Tables 3 and 4, the net reduction in cost for TAGCC technology over either of the competing technologies is also substantial. The ability of these savings to offset the additional capital cost requirement for building an AGCC facility is discussed in more detail below.

The capital cost of conventional PFBC and PCWS technologies is approximately $1000 per kilowatt of electrical generating capacity. TAGCC technology has a capital cost of approximately $1200 to $1400 per kilowatt of capacity. This differential amounts to between 50 and 100 million dollars of increased capital cost for constructing a new facility with 250 megawatts of capacity.

To offset these capital cost differentials, it is critical that state and federal regulatory agencies recognize the value of the environmental benefits of gasification technologies over alternative combustion technologies. These costs include the responsibility from cradle to grave for the safe disposal of hazardous components in solid waste, the elimination of air pollution emissions of heavy metal compounds, and a reduction in emissions of oxides of nitrogen and particulate material. This recognition, when translated into government policies that provide incentives for utilities and others to recognize and reduce the real operating costs for waste disposal and air pollution emissions, will continue to make TAGCC technology even more competitive with conventional technologies.

The general public and government agencies will continue to demand actions by industry to produce a cleaner environment. A prudent operator should anticipate these requirements and select a technology that not only reduces the amount of waste generated, but can actually consume hazardous wastes as well.

If a power generating facility is located in an air pollution non-attainment area that requires emissions reductions, a market-based emissions trading system is one mechanism that will provide additional incentive to pursue TAGCC technology over other alternatives.

Tables 5 and 6 compare the potential value of emissions reduction credits over the life of a project for an TAGCC facility versus PFBC and PCWS facilities, respectively. The current cost of solid waste disposal is relatively easy to quantify compared to air pollution emissions reductions credits. For the purpose of this illustration, it was assumed that the slag generated from gasification would incur no disposal cost since this material has value as a saleable commodity. For these cases no disposal costs were included for the PFBC and PCWS combustion technologies beyond a $20 per ton transportation charge. In addition, no credit was given to TAGCC technology for the recovery of saleable elemental sulfur.

The value of environmental credits, as developed by Pace University, represents reasonable approximations of per-ton control cost for the various pollutants in the United States. It should also be noted that while the United States Government has a stated policy of reducing greenhouse gas emissions, including CO_2 to 1990 levels, the substantial reductions achieved by the TAGCC technology due to its higher overall efficiency were not credited in these cases.

Given the uncertainties in valuing emissions reduction credits, it is difficult to forecast the expected value of these credits at some future date. However, it is not hard to speculate that many regions of the United States will have difficulty demonstrating attainment of the ozone and particulate air quality standards, while continuing to pursue economic growth. These two competing concerns will increase the demand, and, therefore, the value of technologies that can produce emissions reduction credits in the future since the supply of potential credits is limited by the current sources in a region. The requirements for emissions offsets for new and rebuilt sources in most of the U.S. metropolitan areas will also stimulate demand for emissions reduction credits. The same case can be made for expected increases in waste disposal costs as landfill capacity declines over the next decade and increasingly stringent environmental regulations govern disposal of all types of wastes.

Tables 5 and 6 also show the value of this twenty-year stream of credits on a before-tax, discounted cash flow basis, assuming a 10% cost of capital and a 4% inflation rate. Using conservative estimates of emissions credit values, the net present value of these credits would range from 136.8 million dollars to 140.3 million dollars for TAGCC versus PFBC and PCWS technologies, respectively.

Recently, the EPA adopted regulations for reducing emissions of NOx, a component of ozone formation in the major urban areas, with estimated cost per ton of emissions reduced in excess of $7,000. These controls are for both motor vehicle emissions and reformulated gasolines that will be required by early in the next century. These cost-benefit ratios have been determined to be necessary by federal and state regulatory authorities in many regions of the United States. If the Value/Ton Environmental Credits column in Tables 5 and 6 is adjusted to use $7,000 for NOx reduction and the net present values are recalculated, then the advantage of Texaco's Advanced Gasification Technology increases substantially to range from 209 to 318 million dollars on a before-tax basis as is shown in Table 7.

Texaco's Advanced Gasification Combined Cycle technology can also be used by petroleum refiners in producing federally mandated reformulated gasolines. Because of the limits on gasoline, sulfur levels, and distillation ranges, production of these gasolines will require the expansion of hydrogen-consuming processes like catalytic hydrotreating and hydrocracking. Concurrently, limits on gasoline benzene content will move refiners towards lowering catalytic reformer severities, which will reduce hydrogen production. TAGCC technology can be used to convert low-value petroleum coke, gaseous fuels, and refinery organic wastes to produce electricity, steam, and hydrogen for refinery utilization. This will reduce refiner utility costs, allow for optimization of coker operations through crude oil selection and coker liquids yield, and provide a means of cost effectively disposing of organic wastes produced at the refinery. These multiple benefits are expected to make TAGCC an important technology in the evolution of the refining industry over the next decade.

Conclusion:

Inherently low emissions technologies like Texaco's advanced gasification process that produce significantly lower levels of pollution will have an increasing competitive advantage in the future. An important factor in expanding the commercialization of innovative technologies like Texaco's AGCC is their ability to capture the true value of environmental credits. This ability is, in large part, dependent on the level of support given by state and federal regulatory agencies and policymakers in promoting markets for environmental credits. In many cases, these are the same government agencies that are promoting alternative fuels as clean fuels for transportation purposes.

Texaco's AGCC has the potential to be more cost competitive than current technologies used for electricity generation when environmental benefits are considered. The value of these credits should increase in the future as more areas struggle to balance the demands for environmental compliance with the need for economic growth. It is critical that the private sector work with state and federal regulators to recognize the value of environmental credits by establishing market-based mechanisms that will provide incentives for innovative technologies to emerge.

Table 1
OPERATING ASSUMPTIONS

	Advanced Gasification Comb. Cycle	Pulverized Coal with Scrubbers	Pressurized Fluidized Bed
Capacity - Tons Coal / Day	2,378	2,881	2,786
% Sulfur Removal	99%	95%	95%
Coal HHV - Btu / Lb	10,100	10,100	10,100
Heat Rate - Btu / kwh	6,000	9,700	9,378
Operational Life - Years	20	20	20
Availability %	80.0%	80.0%	80.0%
Annual Availability Hours	7,008	7,008	7,008
Output Megawatts - Mw	250.0	250.0	250.0
Megawatt Hours - Yr	1,752,000	1,752,000	1,752,000
MMBTU's Consumed / Yr	14,016,000	18,994,400	16,430,256

Table 2
ANNUAL EMISSIONS - Tons Per Year

1. BASIS EPRI 10/91 TECH ASSESSMENT GUIDE DATA
2. BASIS TEXACO TEST DATA

	Advanced (2) Gasification Comb. Cycle	Pulverized (1) Coal with Scrubbers	Pressurized (1) Fluidized Bed
Sulfur Dioxides (SOx)	(.08)* 551	(0.40)* 3,378	(.40)* 3,249
Nitrogen Oxides (NOx)	(.06)* 449	(0.40)* 3,402	(.20)* 1,650
Carbon Dioxide (CO2)	(205)* 1,440,002	(210)* 1,787,500	(224)* 1,842,250
Particulates	(NA) 1	(0.10) 75	(0.09) 77
Solid Waste	135,500	324,000	454,002

* Rate in Parenthesis Based on Lbs of Emissions Per Million BTU's of Heat Input.

Table 3
ENVIRONMENTAL CREDIT VALUATION AGCC vs. PFBC

	Reduced Emissions	Value Per Ton	Basis/ Source	Total (000)
Sulfur Dioxides (SOx)	53,947	$350.00	Pace '92	$18,881
Nitrogen Oxides (NOx)	24,017	$1,640.00	Pace '92	$39,386
Carbon Dioxide (CO2)	8,044,965	$14.00	Pace '92	$112,630
Particulates	1,516	$2,380.00	Pace '92	$3,614
Solid Waste	9,080,000	$20.00	Transport	$181,600
Total				$356,113

Table 4
ENVIRONMENTAL CREDIT VALUATION IGCC vs. PC W/SCRUBBERS

	Reduced Emissions	Value Per Ton	Basis/ Source	Total (000)
Sulfur Dioxides (SOx)	56,502	$350.00	Pace '92	$19,776
Nitrogen Oxides (NOx)	59,057	$1,640.00	Pace '92	$96,853
Carbon Dioxide (CO2)	6,949,965	$14.00	Pace '92	$97,300
Particulates	1,482	$2,380.00	Pace '92	$3,527
Solid Waste	6,480,000	$20.00	Transport	$129,600
Total				$347,056

Table 5

AGCC vs. PRESSURIZED FLUID BED - PFBC

CAPITAL COST ASSUMPTIONS				Dollars Per Kilowatt
PFBC Capital Cost				$1,000
AGCC Capital Cost				$1,200 - $1,400
Incremental Investment (250 MW Plant)				$50 - $100 Million

AGCC POLLUTION CREDIT VALUE		Lifetime Emissions Saved (Tons)	Value/Ton Evironmental Credits	Total Offset Values (Millions)
SULFUR	SOx	53,947	$350	$18.9
NITROGEN	NOx	24,017	$1,640	$39.4
CARBON DIOXIDE	CO2	8,045,965	$0.0	$0.0
PARTICULATES		1,518	$2,380	$3.6
SOLID WASTES		9,080,000	$20	$181.6
TOTAL NPV (Before Tax) 10% Cost of Capital 4% Escalation				$136.8

Table 6

AGCC vs. PRESSURIZED COAL W/SCRUBBERS

CAPITAL COST ASSUMPTIONS				Dollars Per Kilowatt
PFBC Capital Cost				$1,000
AGCC Capital Cost				$1,200 - $1,400
Incremental Investment (250 MW Plant)				$50 - $100 Million

AGCC POLLUTION CREDIT VALUE		Lifetime Emissions Saved (Tons)	Value/Ton Evironmental Credits	Total Offset Values (Millions)
SULFUR	SOx	56,600	$350	$19.8
NITROGEN	NOx	59,100	$1,640	$96.9
CARBON DIOXIDE	CO2	6,950,000	$0.0	$0.0
PARTICULATES		1,482	$2,380	$3.5
SOLID WASTES		6,480,000	$20	$129.6
TOTAL NPV (Before Tax) 10% Cost of Capital 4% Escalation				$140.3

Table 7

NPV OF POLLUTION CREDIT
HIGH VALUATION FOR NOx CASE

ASSUME: Value of NOx reduction increased to $7000 / ton
all other values held constant
Cost of Capital - 10%
Inflation Rate - 4%
Before Tax Basis

NET PRESENT VALUE - TAGCC vs. PFBC Technology:
209 Million Dollars

NET PRESENT VALUE - TAGCC vs. PCWS Technology:
318 Million Dollars